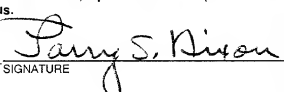


| | | |
|---|---|---|
| FORM PTO-1390 (REV 11-2000) | U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | ATTORNEY'S DOCKET NUMBER 36-1417 |
| TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371 | | U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) 09/806576 Unknown |
| INTERNATIONAL APPLICATION NO. PCT/GB99/03416 | INTERNATIONAL FILING DATE 15 October 1999 | PRIORITY DATE CLAIMED 30 October 1998 |
| TITLE OF INVENTION DATA TRANSPORT | | |
| APPLICANT(S) FOR DO/EO/US DALBY et al | | |
| Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information: | | |
| <p>1. <input checked="" type="checkbox"/> This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.</p> <p>2. <input type="checkbox"/> This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.</p> <p>3. <input checked="" type="checkbox"/> This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.</p> <p>4. <input checked="" type="checkbox"/> The U.S. has been elected by the expiration of 19 months from the priority date (Article 31).</p> <p>5. A copy of the International Application as filed (35 U.S.C. 371(c)(2)).</p> <p>a. <input checked="" type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).</p> <p>b. <input type="checkbox"/> has been communicated by the International Bureau.</p> <p>c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</p> <p>6. <input type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</p> <p>a. <input type="checkbox"/> is attached hereto.</p> <p>b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4).</p> <p>7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).</p> <p>a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).</p> <p>b. <input type="checkbox"/> have been communicated by the International Bureau.</p> <p>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</p> <p>d. <input type="checkbox"/> have not been made and will not be made.</p> <p>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</p> <p>9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</p> <p>10. <input type="checkbox"/> A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</p> | | |
| Items 11 To 20 below concern document(s) or information included: | | |
| <p>11. <input type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.</p> <p>12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.</p> <p>13. <input type="checkbox"/> A FIRST preliminary amendment.</p> <p>14. <input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.</p> <p>15. <input type="checkbox"/> A substitute specification.</p> <p>16. <input type="checkbox"/> A change of power of attorney and/or address letter.</p> <p>17. <input type="checkbox"/> A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.</p> <p>18. <input type="checkbox"/> A second copy of the published international application under 35 U.S.C. 154(d)(4).</p> <p>19. <input type="checkbox"/> A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).</p> <p>20. <input checked="" type="checkbox"/> Other items or information. Amended Sheets -- pages 2 and 2a</p> | | |

| | | |
|--|--|--|
| U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.5) 097806576 | INTERNATIONAL APPLICATION NO. PCT/GB99/03416 | ATTORNEY'S DOCKET NUMBER 36-1417 |
| 21. <input checked="" type="checkbox"/> The following fees are submitted: | | CALCULATIONS PTO USE ONLY |
| BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5)): -- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO\$1000.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO\$860.00 -- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO\$710.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)\$690.00 -- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)\$100.00 ENTER APPROPRIATE BASIC FEE AMOUNT = | | \$ 860.00 |
| Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)). | | \$ 0.00 |
| CLAIMS | NUMBER FILED | NUMBER EXTRA |
| Total Claims | 8 | -20 = |
| Independent Claims | 4 | -3 = |
| MULTIPLE DEPENDENT CLAIMS(S) (if applicable) | | \$270.00 |
| TOTAL OF ABOVE CALCULATIONS = | | \$ 940.00 |
| <input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. | | \$ 0.00 |
| SUBTOTAL = | | \$ 940.00 |
| Processing fee of \$130.00, for furnishing the English Translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)). | | \$ 0.00 |
| TOTAL NATIONAL FEE = | | \$ 940.00 |
| Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property + | | \$ 0.00 |
| Fee for Petition to Revive Unintentionally Abandoned Application (\$1240.00 - Small Entity = \$620.00) | | \$ 0.00 |
| TOTAL FEES ENCLOSED = | | \$ 940.00 |
| | | Amount to be: refunded \$ |
| | | Charged \$ |
| a. <input checked="" type="checkbox"/> A check in the amount of \$940.00 to cover the above fees is enclosed. b. <input type="checkbox"/> Please charge my Deposit Account No. 14-1140 in the amount of \$_____ to cover the above fees. A duplicate copy of this form is enclosed. c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fee which may be required, or credit any overpayment to Deposit Account No. 14-1140. A duplicate copy of this form is enclosed. d. <input checked="" type="checkbox"/> The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application. | | |
| NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status. | | |
| SEND ALL CORRESPONDENCE TO: NIXON & VANDERHYE P.C. 1100 North Glebe Road, 8 th Floor Arlington, Virginia 22201-4714 Telephone: (703) 816-4000 | | |
|  SIGNATURE | | |
| Larry S. Nixon NAME | | |
| 25,640 REGISTRATION NUMBER | | April 2, 2001 Date |

5/PRTS

532 Rec'd FROM TFO 02 APR 2001

1

DATA TRANSPORT

This invention relates to transport of data over communications networks and, in particular, to transport of data encoded by layered encoding algorithms.

- 5 Networks based upon the Internet Protocol (IP) are being used increasingly to convey multi-media data transmissions, enabled by the use of compression algorithms to reduce data volumes to sufficiently low levels for transport over relatively low data rate network connections. However, problems remain to be overcome to achieve distribution of multi-media services, audiovisual services for
- 10 example, to a large number of client terminals having a variety of different capabilities for receipt of such services. In particular, some clients may have access only to limited data rate network connections enabling receipt of only low-resolution and low picture rate video. Other users may be connected to relatively high bandwidth corporate LANs and demand higher quality reception. Known
- 15 methods for providing different levels of service to different users include point-to-point services whereby a tailored version of a session is separately transmitted directly to each user at their network address, and "simulcast" techniques whereby a number of different data rate transmissions are broadcast and users may select and share that most suited to their needs. However, both point-to-point
- 20 and simulcast techniques involve significant overlap and duplication of data between transmitted data streams and are clearly inefficient in their consumption of network capacity.

- Layered encoding techniques, such as that implemented for example under the H.263 standard for video data compression, defined in "Video Coding for Low
- 25 Bit Rate Communications", International Telecommunication Union (ITU) - T Recommendation H.263, January 1998, enable data representing different resolutions of video to be encoded as separate layers of data frames. At the lowest layer, layer 0, a "lowest common denominator" encoding may be provided. Frames within layer 0 may provide a relatively low resolution representation of
- 30 original images, not necessarily all the original images. Data frames in higher layers may add increasing levels of detail to representations by lower layer frames or may encode images omitted from the lower layers altogether. Each layer of encoded data frames may be broadcast separately by a server, each layer to a different multi-casting network address. It is intended that most user equipment may be

able to receive the lowest layer 0 by accessing the appropriate multi-cast address for layer 0. Users who so choose, or who have equipment capability to receive higher layers may access one or more of the corresponding network addresses to enjoy a higher quality of audiovisual service. In this way, disparate client needs may be satisfied by a single broadcast of each layer without unnecessary duplication of data.

- Where multi-casting techniques are being used in relation to IP networks, a currently preferred protocol for transporting layers of encoded data frames is the User Datagram Protocol (UDP) as defined in "User Datagram Protocol", Internet RFC 768, J. Postel, August 1980, published on the Internet by the Internet Engineering Task Force (IETF). However, while UDP offers a more rapid procedure for sending messages with a minimum of protocol mechanism, in comparison with the Transmission Control Protocol (TCP) for example, this is achieved at the expense of guaranteed delivery. Data may be lost, perhaps to the extent that a one layer may be lost during conveyance over a network, or at least delayed with respect to other layers. Therefore, besides exercising a choice not to receive a higher layer of encoded data, there are involuntary reasons why a client apparatus may not receive all encoded data broadcast within a session. In both circumstances, problems may arise at a client apparatus in presenting received data to a decoder in the correct order for decoding.

- In Jau-Shiung Huang et al.: "MHTP - A Multimedia High-Speed Transport Protocol", from GLOBECOM '92, Orlando - Communication for Global Users, Dec 6-9, 1992, Volume 3, 6 December 1992, pages 1364-1368, XP000390432 IEEE, a protocol (MHTP) is described that enables packet sequence numbering and packet ordering to be managed within each of several sub-protocols as may each be used to convey a separate layer of multi-layer encoded data. However, MHTP does not solve the problem of how to present received packets, selected from across several sub-protocol layers, to a decoder in the correct order for decoding.

- In "An Efficient Loss-Priority Scheme for MPEG-2 Variable Bit Rate Video for ATM Networks", Wilson, D. and Ghanbari, M., IEEE 1996, Essex University, a technique is described for generating an enhancement layer comprising only B-frames, though relying upon the correct relative timing of the base layer and the enhancement layer being maintained during transmission to ensure correct order

2a

of presentation of encoded frames to a decoder. Any variation in the expected delay between receipt of a first encoded frame from the base layer and the first from the enhancement layer, for example, would not be correctable prior to decoding.

- 5 In Internet RFC 1693: "An Extension to TCP: Partial Order Service", November 1994, an extension to TCP is described for transmitting a service profile during connection setup, defining an acceptable order of receipt for transmitted objects. The service profile includes a partial ordering matrix defining an acceptable order for numbered objects, enabling a receiver to order such
- 10 objects to the extent defined in the profile, even though there may be loss or excessive delay in receiving certain objects. However, the overhead in defining and transmitting service profiles, prior to sending data, increases the complexity of transmitting and receiving apparatus and introduces additional delay.

- According to a first aspect of the present invention, there is provided a
- 15 data streaming apparatus, having:

a data input for receiving data frames encoded by a layered encoding algorithm;

- packetising means to insert received data frames, so encoded, into one or more predetermined packet structures, the data frames associated with each
- 20 encoded layer being inserted into a different respective sequence of packets;

packet numbering means to assign a data sequence number to each packet generated by the packetising means, the data sequence number assigned to a packet being indicative of the order of receipt, at the data input, of encoded data inserted within the packet; and

- 25 a network interface to transmit, in use, packets so created.

The present invention enables a sequence number to be assigned to each data packet, conveying encoded data, representative of the correct order for

subsequent presentation of the encoded data to a decoder. Such a sequence number enables packets received at a client apparatus to be correctly ordered, even when the client apparatus does not receive all the transmitted layers of packets or when individual packets are lost. This is particularly important where
5 differential encoding algorithms are used, such as that defined by the H.263 standard.

Differential encoders, such as those implementing H.263, generate layered data streams each having a highly variable data rate. The quantity of data required to encode each of a sequence of images differs according to the degree of
10 variation between successive images. In general, the order of output of encoded frames by an encoder is the order required for input to a decoder. However, if during transport from encoder to decoder, one layer is lost or delayed significantly with respect to another, or if particular packets are lost, problems arise at the receiving equipment in presenting the received data packets to a decoder in the
15 correct order for decoding. Therefore, while use of multi-layered encoding appears to solve the problem of accommodating different client needs, new problems arise in decoding multi-layered transmissions.

Preferably, a further sequence number may be assigned to each packet representing the order of transmission of the packet, under the control of a
20 selected protocol, within a sequence of packets conveying a particular layer of encoded data frames. Such a sequence number may be used to improve packet ordering efficiency through identifying whether all packets expected within a particular packet sequence have been received and that the next packet for decode must lies in another packet sequence.

25 According to a second aspect of the present invention, there is provided a client apparatus having:

a network interface;

packet receiving means to receive one or more sequences of data packets from the network interface, each data packet having a predetermined packet structure, each
30 of said one or more sequences of data packets conveying a different respective layer of encoded data frames generated by a layered encoding algorithm and each data packet having assigned thereto a data sequence number indicative of the order of output of encoded data, conveyed by the data packet, from said layered encoding algorithm;

packet ordering means to place said received data packets into a decoding order using said data sequence numbers; and

output means to output packets so ordered.

According to a third aspect of the present invention, there is provided
5 method of generating data packets to convey data frames encoded by a layered encoding algorithm for transmission over a communications network, each layer of encoded data frames being conveyed by a different respective sequence of data packets, including the steps of:

- (1) receiving an encoded data frame;
- 10 (2) inserting data from said data frame into one or more data packets generated according to a predetermined packet structure;
- (3) assigning, in respect of one of said one or more data packets, a data sequence number indicative of the order of receipt of encoded data inserted into said packet;
- 15 (4) writing said data sequence number at a predetermined position within said packet; and
- (5) performing steps (3) and (4) in respect of each of said one or more data packets generated at step (2).

According to a fourth aspect of the present invention, there is provided
20 method of ordering data packets received within one or more separately accessible sequences of data packets generated according to the method of Claim 5, including the steps of:

- (1) receiving one or more data packets on one or more of said one or more separately accessible sequences of data packets;
- 25 (2) selecting, from those data packets received at step (1), that data packet having the smallest assigned data sequence number amongst non-selected data packets;
- (3) outputting said selected data packet;
- (4) repeating steps (1) to (3).

30 The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings of which:

Figure 1 shows a video streaming apparatus according to preferred embodiments of the present invention;

Figure 2 shows a client apparatus arranged to receive signals transmitted by the apparatus of Figure 1;

Figure 3 shows a typical hierarchy of layered data frames, encoded from a small sequence of video images, for transmission by the apparatus of Figure 1;

5 Figure 4 shows the result of applying a packet numbering algorithm, according to preferred embodiments of the present invention, to packets generated to convey encoded data frames shown in Figure 3;

Figure 5 shows the structure of a packet header according to the Real-time Transport Protocol (RTP) as used in a preferred embodiment of the present
10 invention; and

Figure 6 is a flow diagram showing steps in the operation of a preferred client apparatus, relating in particular to the ordering of packets broadcast by the apparatus of Figure 1.

Preferred embodiments of the present invention will now be described
15 in the particular context of a video streaming apparatus, although the present invention may be applied to other forms of data broadcast and receiving apparatus, not necessarily in a client-server arrangement, involved in a single or multi-media session with data encoded by layered encoding techniques.

Referring to Figure 1, a video streaming apparatus 100 is shown,
20 according to preferred embodiments of the present invention, for use in broadcasting multi-layer encoded audiovisual data from an encoded audio/video data source 105 to client systems over a communications network 110. The audio/video data source 105 may for example be a database of encoded video data for use in a "video-on-demand" system, or it may be a multi-layer encoded real-
25 time audiovisual data stream to be transmitted as a live broadcast. The video streaming apparatus 100 accepts layers of encoded data from the source 105 at an input 115 before passing them to a packetiser 120. The packetiser 120 may implement a known algorithm for separately incorporating data from each layer of encoded data into a different respective stream of packets according to one or
30 more predetermined packet structures. For example, one or more layers may be incorporated into packets having a structure defined for use with the Real-Time Transport Protocol (RTP), described by Internet Request for Comment (RFC) 1889, January 1996 - "RTP: A Transport Protocol for Real-Time Applications" by H.Schulzrinne, S.Casner, R.Frederick and V.Jacobson, and published on the

Internet by the Internet Engineering Task Force (IETF). Once arranged according to their respective predetermined packet structure, the layers of packets are passed to a packet numbering module 125 to be numbered by a packet numbering method according to preferred embodiments of the present invention. The numbered
5 packets are then passed to instances of a session handler 130, one instance of session handler per layer of packets. Each instance of session handler 130 may implement an appropriate protocol to control transfer of the respective layer of packets over the communications network 110, via a network interface 135, to one or more predetermined network addresses, multi-cast addresses for example.
10 Protocols operating at lower levels in a protocol hierarchy of may be implemented by the network interface 135 as appropriate to the communications network 110. For example, at the level below RTP, the User Datagram Protocol (UDP) referenced above may be implemented by the network interface 135 to operate in conjunction with the Internet Protocol (IP).
15 Preferably, for simplicity, all layers of encoded data may be broadcast under the control, at the session level at least, of respective instances of the same protocol using the same packet structure. However, the scope of the present invention is intended to encompass those situations in which more than one type of protocol is employed to broadcast layers of encoded data received at the input
20 115.

Referring to Figure 2, a typical client apparatus 200 is shown for use in receiving, over the communications network 110, audio and/or video broadcasts by one or more sources having features in common with the video streaming apparatus 100 of Figure 1. The client apparatus 200 may create instances of a
25 session handler 210, each instance of session handler 210 "listening" for data received at a particular network address, one instance corresponding to each layer of packets received over the network via a network interface 205. The received layers of packets pass from their respective session handlers 210 into a source demultiplexer 215. In the event that multiple video streamers or other types of
30 source are broadcasting on the same session, each source may preferably be separately identifiable by the source demultiplexer 215 using information inserted into packet headers by the respective source streamer. For each distinct source identified, the source demultiplexer may create one instance of a blender 220, collating all packets received via the session handlers 210 carrying the same

source identifier, and passing the collated packets to the blender 220. The blender 220 may implement an algorithm, according to preferred embodiments of the present invention, for ordering packets received from the particular source using packet numbering information inserted by the packet numbering module 125 of the respective source, video streamer 100 for example. Having established the correct packet order, taking account of any missing or inaccessible layers and packets, the blender 220 may pass the ordered packets to a depacketiser 225 to recover the layers of encoded data from the respective predetermined packet structure used by the particular streaming source, by packetiser 120 in the case of a video streamer 100. The depacketiser 225 passes the recovered encoded data, now in the correct sequence for decoding, to an output 230. The ordered data output from the client apparatus 200 may be taken by an appropriate decoder and, following decoding, reproduced at a display and/or audio output apparatus as appropriate.

Referring to Figure 3, a typical hierarchy of layered data frames is shown, encoded from a small sequence of video images, as might be presented to the input 115 of a video streamer 100. The encoded frames 340 are shown arranged as three layers, 300, 305 and 310 corresponding to a lowest layer, a middle layer and a top layer respectively. Further layers may be generated according to the particular encoding algorithm implemented by the source 105. Each encoded frame 340 of Figure 3 is shown with a number in the range 1 to 10, indicating the order of output by the encoded data source 105 and hence the required order for subsequent presentation of the frames to a decoder. The frames 340 in Figure 3 are shown grouped within five columns, each column of frames being encoded to represent a respective original image 315-335. For example, original image "A" 315, is shown encoded as a frame number "1" in the lowest layer 300, a frame "2" in middle layer 305 and a frame "3" in the top layer 310. Original image "B" 320 is represented only in the top layer 310 by a frame generated with number "4". The original image data 315-335 would not normally be presented to the input 115 of a video streaming apparatus 100.

30 The sequence of encoded frames 1-10 of Figure 3 may, for example, be generated according to a video encoding algorithm such as H.263, referenced above. If the H.263 encoding technique is used to encode the images 315-335 of Figure 3, each frame 340 in the lowest layer 300 may represent a low-resolution version of the respective original image and may be encoded using the basic H.263

algorithm at QCIF resolution as described in Section 4.1 of the referenced specification. Frames in layers 305 and 310 represent increasingly detailed enhancements to the low-resolution image represented by the respective frame in layer 300. Under H.263, the middle and top layers may be encoded according to

5 the definition in Annex O, "Temporal, SNR and Spatial Scalability Mode", of the above-referenced H.263 specification.

Not all original images may be represented in the lower layers 300, 305. In the particular sequence shown in Figure 3, only every fourth original image is represented in the lowest layer 300 and every second original image in the middle

10 layer 305. Thus, a client apparatus able or choosing to decode only the lowest layer of frames will display a representation of the original sequence of images having a relatively low resolution and a relatively low image rate as compared with client apparatus able or choosing to decode both the lowest and middle layers. Apparatus able to receive and decode all three broadcast layers 300-310 will be

15 able to display all the original images (315-335) at the highest resolution available. It is intended that a lower data rate network connection may be used to receive data frames at the lowest layer, making that layer accessible to most client equipment.

Referring to Figure 4, a diagram is provided to show a typical breakdown

20 of those encoded frames 340, representing the first three original images 315, 320 and 325 of Figure 3, across corresponding layered sequences of packets 400 by the packetiser 120. Figure 4 also shows the result of applying a packet numbering scheme to those packets as may be implemented by the packet numbering module 125 according to preferred embodiments of the present invention. A typical

25 packetiser 120 may operate to packetise each layer of encoded frames separately, generating, as in the present example, three separate streams of packets, one stream for each layer. As discussed in relation to Figure 1 above, the packetiser 120 may be arranged to implement one or more packet structures appropriate to the particular protocol chosen at the session level to control the conveyance of

30 each encoded layer of data. Preferably, each layer of encoded data may be conveyed over a network using a different respective instance of the Real-time Transport Protocol (RTP) referenced above. The packetiser 120 would, in that case, split the data within a layer of encoded frames 340 across the payload portions of a sequence of RTP packets, according to the RTP packet structure

definition. Conveniently, if packetising data encoded using the H.263 algorithm referenced above, a specific definition of an H.263 payload header is available for inclusion in RTP packets, as defined in "RTP Payload Format for H.263 Video Streams", Internet RFC 2190, September 1997, published on the Internet by the IETF. Alternative and equally satisfactory session-level protocols may be selected for implementation by the packetiser 120, employing their own respective packet structures to convey the encoded layers 300-310 of data frames 340.

- Referring to Figure 4, as indicated above, each of the packets 400 is shown labelled with sequence numbers applied by packet numbering module 125.
- 10 A preferred method of numbering involves the assignment of two sequence numbers to each packet 400. The number shown in the upper half of each packet 400 of Figure 4 may be referred to as a "layer sequence number" LSEQ, while the number shown in the lower half of each packet may be referred to as a "cross-layer sequence number" XSEQ. The sequence of LSEQ numbers indicates the order
- 15 of transmission of packets within one specific layer. The XSEQ numbers are intended to represent the correct overall order for presentation of encoded data conveyed by those packets to a decoder 225 at a client apparatus 200. The XSEQ sequence reflects, in particular, the order that encoded data frames emerged from the source 105.
- 20 Protocols such as RTP provide a facility to assign sequence numbers to packets within a particular RTP packet stream. In this case, each layer of encoded data may be broadcast as a separate RTP packet stream under the control of different RTP session. Hence, within one layer, the respective (RTP) session handler 130 may automatically assign a layer sequence number LSEQ to each
- 25 packet before transmission and write the sequence number at a predetermined position with the packet. Other types of protocol may not provide such a facility for assignment of layer sequence numbers. Hence the packet numbering module 125 may implement both layer sequence number assignment and cross-layer sequence number assignment if required.
- 30 With different layers being typically broadcast under the control of separate protocol sessions, as with RTP, there is no overall mechanism for assigning XSEQ numbers across layers. In order to assign a sequence of XSEQ numbers in particular, the packet numbering module 125 may be provided at a point immediately following the packetiser 120 and immediately before the

individual packet streams go to their respective session handlers 130 for broadcast. If required, the packet numbering module 125 may retain access to information on the order of receipt of encoded data frames at the input 115 in order to correctly assign XSEQ numbers to packets emerging from the packetiser

- 5 120. It is particularly important, when encoding data using a differential encoding algorithm such as that defined by H.263, to subsequently decode those data in the correct sequence. Assignment of an XSEQ number by the packet numbering module 125 provides a particularly convenient method of recording the correct data sequence at the packet level. Data loss or reordering of data typically occurs
- 10 at the packet level. As will be discussed in the following, recording of a layer sequence number LSEQ and, in particular, a cross-layer sequence number XSEQ enables a client apparatus 200, according to preferred embodiments of the present invention, to re-order packets received out of sequence and to take account of missing packets and missing or inaccessible encoded data layers.

- 15 Referring to Figure 5, the packet header structure defined for use under RTP is shown. The RTP packet structure may be used by preferred embodiments of the present invention to record packet sequence numbers. Figure 5a shows the RTP header structure, including an optional RTP Header Extension, while Figure 5b shows the structure of the header extension itself, all details of which are
- 20 described by the above-referenced RTP definition document. The RTP packet header of Figure 5a includes a Sequence Number field occupying the third and fourth octets. This field is used within the RTP protocol to record the transmission order of packets within the particular packet stream and may therefore perform the role of the layer sequence number LSEQ.

- 25 To accommodate the cross-layer sequence number XSEQ, the packet numbering module 125 may preferably use the optional RTP header extension, shown in Figure 5a at a position immediately following the "Contributing Source (CSRC) Identifiers". With this intention, the packetiser 120 may set the extension bit "X" - bit 4 of the RTP header - and include one RTP Packet Header extension,
- 30 having the structure shown in Figure 5b, within each generated packet. Within each packet, the packetiser 120 may record a unique profile-specific identifier within the "profile" field of the header extension and may set the "length" field to 1, including one 32 bit "header extension" field. Such an extension field length should be adequate for use in recording XSEQ numbers generated within a typical

multi-media session. The packet numbering module 125 may then write an appropriate XSEQ number into the extension field of each packet received from the packetiser 120.

- While the RTP packet structure includes fields suitable for recording assigned sequence numbers, other protocols and packet structures may not provide predetermined positions within their packets to carry sequence number information. If necessary, one or more further packet data streams may need to be generated by the packetiser 120, to be transmitted approximately in synchronisation with other packet streams, to convey sequence numbering information assigned by the packet numbering module 125 and linked, for example by a packet identifier, to packets carrying encoded data. On receipt of the "sequence number packet stream", a client apparatus may extract and use the sequence numbering information in much the same way as described below.

- As discussed above in relation to the identification of a transmitting source by the source demultiplexer 215 of a client apparatus 200, for example where multiple video streamers 100 are transmitting RTP packets over the communications network 110, the "SSRC" field in the RTP header of Figure 5a may be used by an RTP session handler 130 to record within each RTP packet an identifier for the particular video streamer 100 generating the packet. The source demultiplexer 215 of a client apparatus 200 may then read the SSRC field in received packets to distinguish between packets from one video streamer and another.

- Referring to Figure 6, a flow diagram is provided to show a sequence of steps in operation of an instance of a blender 220 relating to the ordering of packets, received from a particular streamer 100, numbered by a packet numbering module 125, according to preferred embodiments of the present invention. Preferably, a variable "TOP_LAYER" may be set at a predetermined value in a particular client apparatus 200, to record the highest numbered layer that the particular apparatus is set to receive and decode, either by choice or as limited by equipment capability or network connection bandwidth. The TOP_LAYER value may be set within the range 0 to n, where n is the highest numbered layer transmitted by data streaming sources accessible over the network 110.

Referring to Figure 6, processing by the blender 220 may be seen to begin at STEP 600. At STEP 602, a pre-processing step is performed on packets already

received to place them into layer sequence number (LSEQ) order within their respective layer. Ordering of packets by LSEQ number may be implemented by a known and simple ordering algorithm and, as such, further detail of STEP 602 will not be discussed in this specification.

- 5 At STEP 605, the blender 220 reads the first received packet on layer 0 (PKT[0]) and uses the layer sequence number (LSEQ) and cross-layer sequence number (XSEQ) contained in that packet to initialise counters LPROG[] and XPROG respectively for use in determining the next expected number in each of the packet numbering sequences. At STEP 610, variables are initialised ready for processing
- 10 packets from the currently selected layer, layer 0 initially. At STEP 615, an attempt is made to read the packet having the lowest layer sequence number (LSEQ) from the layer (L) currently being processed (initially layer L=0). Packets already received in time for operation of STEP 602 will have been ordered by layer sequence number so that, among those already received, the next packet read
- 15 from the layer L may be assumed to have the lowest LSEQ number. If, at STEP 620, a packet is available in layer L, then, at STEP 625, the cross-layer sequence number (XSEQ) in that packet is compared with the next expected cross-layer sequence number. If, at STEP 625, the current packet is the next in the cross-layer sequence then, at STEP 660, the current packet sequence numbers are used to set
- 20 the XPROG and LPROG[L] counter variables before, at STEP 665, that packet is forwarded to the decoder 225.

If, at STEP 620, no packet is available on the current layer, then at STEP 675 a flag is set to indicate that packets are unavailable on a layer and processing proceeds to STEP 640 to enable higher layers to be accessed in search of packets.

- 25 If, at STEP 625, the current packet is not the next in the cross-layer sequence, then either the next expected packet is missing from within the current layer or it lies in another layer. A following sequence of steps attempts to establish whether the next expected packet for decoding is currently missing – possibly delayed - within the current layer, or whether it may be found in another accessible
- 30 layer. Therefore, at STEP 630, the blender 220 first checks whether the current packet is the next expected packet within the current layer (L). If not, then at STEP 670 a flag is set to indicate that the current packet is out of sequence in its layer before processing continues to STEP 635. If, at STEP 630, the current packet was the next expected packet in its layer, then the packet having the next

expected XSEQ number must lie in another layer. However, in case the packet is soon found not to lie in a layer accessible by the client apparatus 200, or to be otherwise lost (from STEP 670), then at STEP 635 a variable recording the smallest recently encountered XSEQ number is updated along with the layer in which that respective packet was found. This will be the point of continuation in processing if the packet with the next expected XSEQ number is not located in any of the accessible layers. But first, any other accessible layers are checked.

The layer number is incremented at STEP 640. If the new current layer is at or below the highest layer accessible to the client apparatus at STEP 645, then processing returns to STEP 615 and the next expected packet is sought within that layer as described above. However, if at STEP 645, the new current layer is inaccessible then, at STEP 650, a check is made to determine whether packets are currently unavailable on any layer. If, at STEP 650, one or more layers have no received packets available, then processing restarts at STEP 610, looking again for the next expected packet, beginning at layer 0. If, at STEP 650, all layers have at least one packet available, then at STEP 652 it is determined whether or not the current packet is the next expected packet within its layer. If, at STEP 652 the current packet is correctly ordered within its layer, then the next expected packet in the XSEQ order must lie in a higher layer, one that is not accessible to the particular client apparatus 200. Therefore, the best that can be achieved is to select the packet with lowest XSEQ number on any layer. Therefore, at STEP 655, the layer having the packet with the lowest XSEQ number is selected as the new current layer, and that selected packet is treated as the next available packet for decoding. The XPROG and LPROG[L] sequence number counters are reset to the current packet values at STEP 660 and the selected packet is sent for decoding at STEP 665.

If, at STEP 652, the current packet was out of sequence within its layer, then at STEP 680, the blender 220 may optionally elect to wait for the next one or two packets to arrive on that layer for example, in case the next expected packet within the layer arrives (in which case processing would restart at STEP 610) or to continue without further delay to STEP 685 and select the layer having the packet with the lowest XSEQ number as the new current layer, and select that packet as the next available packet for decoding, proceeding to STEP 660.

After sending a packet for decoding at STEP 665, processing returns to step 610, resetting variables related to out-of-sequence processing and resetting the layer number L to 0, before continuing as described above.

It will be clear that more sophisticated processing steps may be included to implement different strategies in the event that, at STEP 652, received packets within a layer are out of sequence within that layer. If the nature of the communications network 110, or the protocols selected to transfer packets across it, are such that individual packets may be delayed within a layer, then it may be beneficial to implement more sophisticated waiting algorithms if there is a possibility that the expected packet may arrive later. Such a strategy is suggested in STEP 680 of Figure 6 without going into detail. Alternatively, with pure audio data for example, the effect of a lost packet may be partially overcome by inserting a duplicate of the immediately preceding packet, rather than leave a gap or risk further delay. An equivalent strategy may be available with encoded video data, if manageable under the selected encoding/decoding algorithm.

Preferably, a more sophisticated algorithm may be implemented to merge the ordering of received data packets within a layer with processing steps indicated within Figure 6 from STEP 605 onwards, rather than perform pre-processing to order received data packets by LSEQ number within each layer.

20

CLAIMS

1. A data streaming apparatus, having:
 - a data input for receiving data frames encoded by a layered encoding
- 5 algorithm;
 - packetising means to insert received data frames, so encoded, into one or more predetermined packet structures, the data frames associated with each encoded layer being inserted into a different respective sequence of packets;
 - packet numbering means to assign a data sequence number to each
 - 10 packet generated by the packetising means, the data sequence number assigned to a packet being indicative of the order of receipt, at the data input, of encoded data inserted within the packet; and
 - a network interface to transmit, in use, packets so created.
- 15 2. A data streaming apparatus according to Claim 1, wherein the packet numbering means are arranged to assign a further sequence number to each packet generated by the packetising means, said further sequence number being indicative of the position of the packet within the respective sequence of packets.
- 20 3. A data streaming apparatus according to Claim 1, wherein the packetising means are arranged to generate one or more further sequences of packets for use in conveying data sequence numbers assigned by the packet numbering means.
4. A client apparatus having:
 - 25 a network interface;
 - packet receiving means to receive one or more sequences of data packets from the network interface, each data packet having a predetermined packet structure, each of said one or more sequences of data packets conveying a different respective layer of encoded data frames generated by a layered encoding algorithm and each
 - 30 data packet having assigned thereto a data sequence number indicative of the order of output of encoded data, conveyed by the data packet, from said layered encoding algorithm;
 - packet ordering means to place said received data packets into a decoding order using said data sequence numbers; and

output means to output packets so ordered.

5. A method of generating data packets to convey data frames encoded by a layered encoding algorithm for transmission over a communications network, each layer of encoded data frames being conveyed by a different respective sequence of data packets, including the steps of:
- (1) receiving an encoded data frame;
 - (2) inserting data from said data frame into one or more data packets generated according to a predetermined packet structure;
 - 10 (3) assigning, in respect of one of said one or more data packets, a data sequence number indicative of the order of receipt of encoded data inserted into said packet;
 - (4) writing said data sequence number at a predetermined position within said packet; and
 - 15 (5) performing steps (3) and (4) in respect of each of said one or more data packets generated at step (2).
6. A method of generating data packets according to Claim 5, wherein step (3) includes assigning a further sequence number to said one of said one or more data packets indicative of the order of transmission of said data packet within a respective sequence of packets, and wherein step (4) includes writing said further sequence number at a further predetermined position within said data packet.
7. A method of ordering data packets received within one or more separately accessible sequences of data packets generated according to the method of Claim 5, including the steps of:
- (1) receiving one or more data packets on one or more of said one or more separately accessible sequences of data packets;
 - (2) selecting, from those data packets received at step (1), that data packet having the smallest assigned data sequence number amongst non-selected data packets;
 - (3) outputting said selected data packet;
 - (4) repeating steps (1) to (3).

8. A method of ordering data packets within one or more separately accessible sequences of data packets received over a communications network, each sequence of data packets conveying data frames relating to a different layer of encoded data frames output by a layered encoding algorithm, each data packet
- 5 having assigned thereto a data sequence number indicative of the order of output of encoded data, conveyed by said data packet, from said encoding algorithm, and a further sequence number indicative of the position of said data packet within the respective sequence of data packets, the method comprising selecting data
- 10 packets in order of receipt within a first of said accessible sequences of data packets, outputting selected packets from said first sequence in order of assigned data sequence number and, upon selecting a packet from said first sequence having an out-of-sequence data sequence number, using the further sequence
- 15 sequence of data packets.

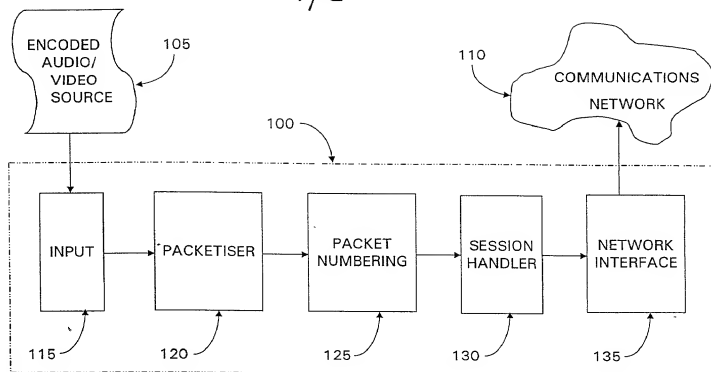
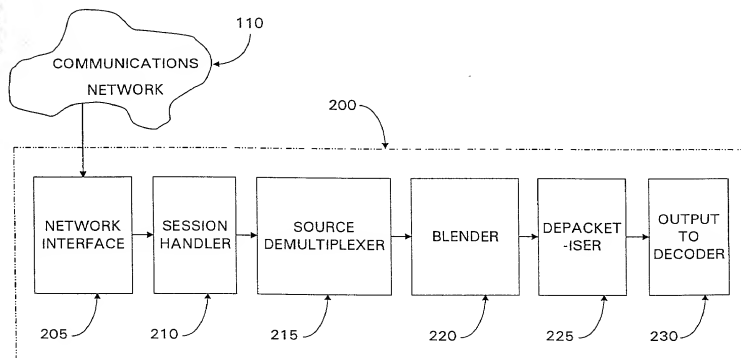
ABSTRACT DATA TRANSPORT

A data streaming apparatus (100) is provided for broadcasting data, encoded by a layered encoding algorithm, each layer of encoded data frames being conveyed within separate respective streams of data packets of a predetermined packet structure, including a packet numbering facility (125) to assign to each data packet a data sequence number indicating the correct order for subsequent decoding of encoded data conveyed by that packet. Corresponding client apparatus (200) is also provided to receive data packets having such data sequence numbers assigned to them, including a packet ordering facility (220) to place out-of-sequence packets into the correct order for output to a decoder.

Figure 1

15

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185

**Figure 1****Figure 2**

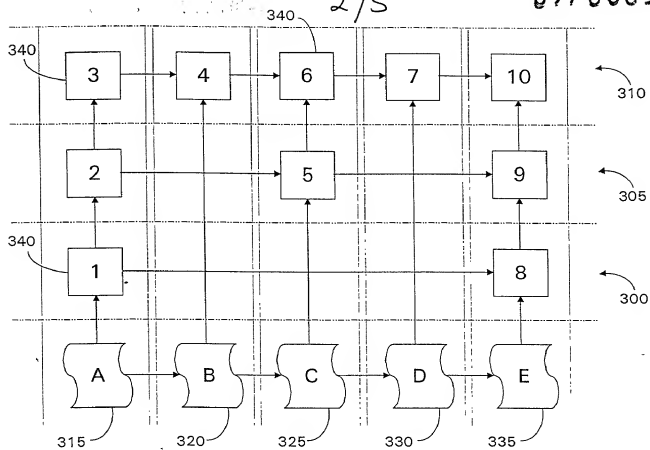


Figure 3

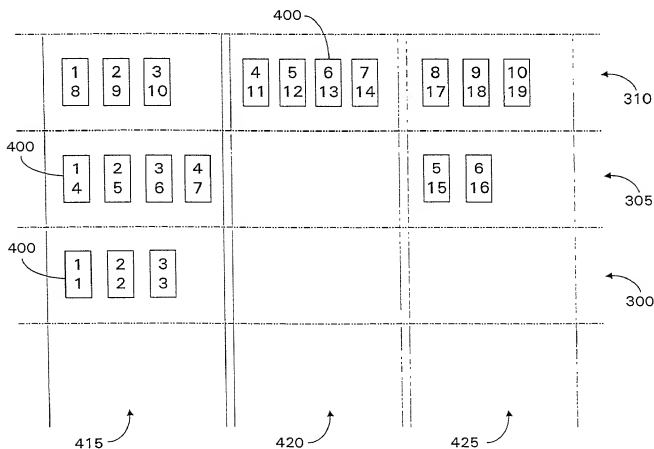


Figure 4

3/5

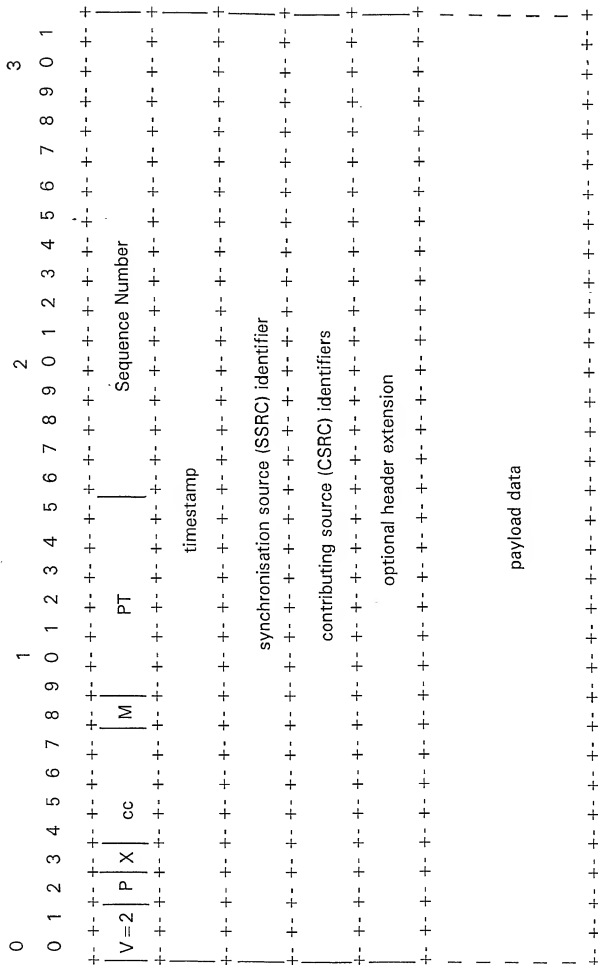


FIGURE 5a

09/806576

4/5

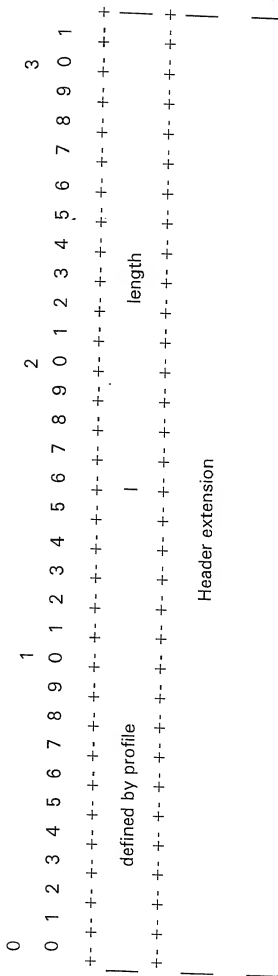


FIGURE 5b

s/s

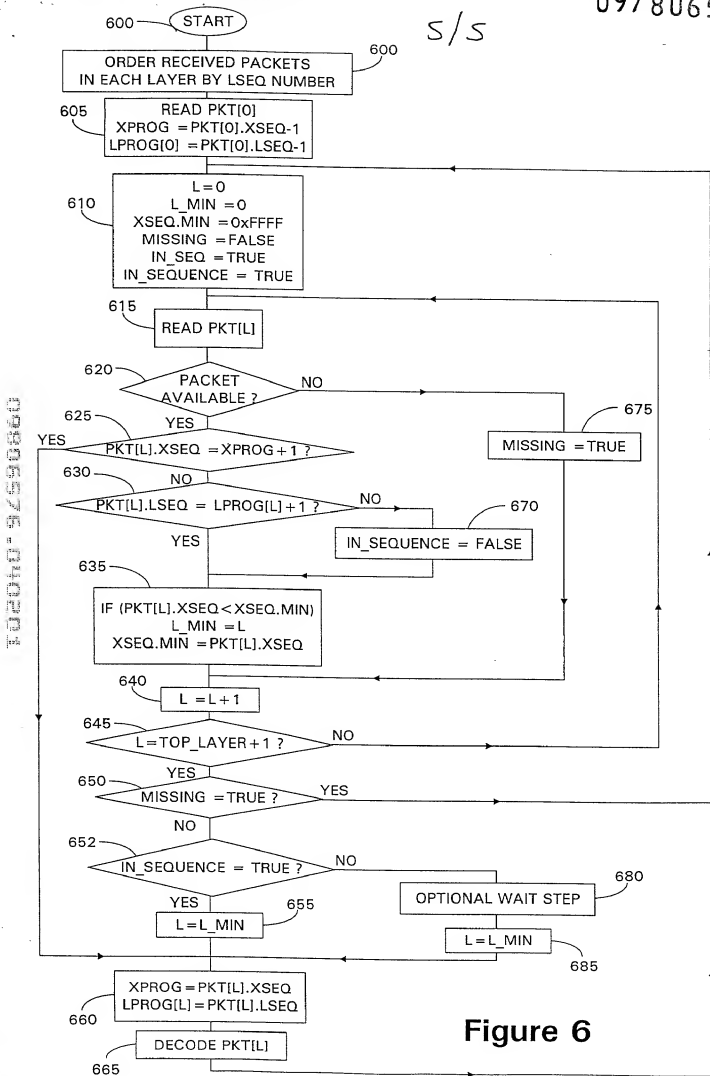


Figure 6

RULE 63 (37 C.F.R. 1.63)
DECLARATION AND POWER OF ATTORNEY
FOR PATENT APPLICATION
IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **DATA TRANSPORT**
the specification of which (check applicable box(es)):

☐ is attached hereto.

☐ was filed on _____ as U.S. Application Serial No. _____

☒ was filed as PCT international application No. PCT/ GB99/03416 on 15 October 1999

and (if applicable to U.S. or PCT application) was amended on _____

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the examination of this application in accordance with 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed or, if no priority is claimed, before the filing date of this application:

Prior Foreign Application(s):

| Application Number | Country | Day/Month/Year Filed |
|--------------------|---------------|------------------------|
| <u>98308894.9</u> | <u>EUROPE</u> | <u>30 October 1998</u> |

I hereby claim the benefit under 35 U.S.C. § 119(e) of any United States provisional application(s) listed below.

| Application Number | Day/Month/Year Filed |
|--------------------|----------------------|
| _____ | _____ |

I hereby claim the benefit under 35 U.S.C. 120/365 of all prior United States and PCT international applications listed above or below and, insofar as the subject matter of each of the claims of this application is not disclosed in such prior applications in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. 1.56 which occurred between the filing date of the prior applications and the national or PCT international filing date of this application:

Prior U.S./PCT Application(s):

| Application Serial No. | Day/Month/Year Filed | Status: patented, pending, abandoned |
|------------------------|------------------------|---|
| <u>PCT/GB99/03416</u> | <u>15 October 1999</u> | <u>PENDING</u> |

I hereby declare that all statements made herein of my own knowledge are true and that statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. And I hereby appoint NIXON & VANDERHYE P.C., 1100 North Glebe Road, 8th Floor, Arlington, VA 22201-4714, telephone number (703) 816-4000 to whom all communications are to be directed, and the following attorneys thereof (of the same address) individually and collectively my power to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent: Arthur R Crawford, 25327-Larry S. Nixon, 25640; Robert A. Vanderhye, 27076-James T. Hosmer, 30184; Robert W. Faris, 31352; Richard G. Besha, 22270; Mark E. Nushbaum, 32348; Michael J. Keenan, 32106; Bryan H. Davidson, 30254; Stanley C. Spooner, 27393; Leonard C. Mitchard, 29009; Duane M. Byers, 33363; Paul J. Henon, 33626; Jeffry H. Nelson, 30481; John R. Lastova, 33449; H. Warren Burnam Jr., 29366; Thomas E. Byrne, 32205; Mary J. Wilson, 32955; J. Scott Davidson, 33489; Alan M. Kagen, 36478; William J. Griffith, 31260; Robert A. Molan, 29834.

1. Inventor's Signature: David Dalby Date: 25/10/99
Inventor: DAVID (first) DALBY (last) BRITISH (citizenship)
Residence: (city) SUFFOLK (state/country) GREAT BRITAIN
Post Office Address: 25 BENNETT AVENUE, ELMSWELL, BURY ST EDMUNDS, SUFFOLK GREAT BRITAIN
(Zip code) IP30 9EZ

2. Inventor's Signature: John O'Donnell Date: 25/10/1999
Inventor: JOHN (first) MARTIN (last) O'DONNELL (last) BRITISH (citizenship)
Residence: (city) SUFFOLK (state/country) GREAT BRITAIN
Post Office Address: 86 TUDENHAM AVENUE, IPSWICH, SUFFOLK, GREAT BRITAIN
(Zip code) CIP4 2HG